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P01/7700 0.00-0316584.2

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2. Patent application number *(The Patent Office will fill in this part)* — 0316584.2 — 16 JUL 2003

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   Xaar Technology Limited,
   Science Park,
   Cambridge,
   CB4 0XR

   Patents ADP number *(if you know it)* — 7301872003

   If the applicant is a corporate body, give the country/state of its incorporation — UK

4. Title of the invention — Droplet Deposition Apparatus

5. Name of your agent *(if you have one)* — Xaar Technology Limited,

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   Science Park,
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   CB4 0XR

   Patents ADP number *(if you know it)* -

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Droplet Deposition Apparatus

The present invention relates to printers and in particular droplet deposition ink jet printers

Ink jet printers are no longer viewed simply as office printers, their versatility means that they are now used in digital presses and other industrial markets. It is not uncommon for print heads to contain in excess of 500 nozzles and it is anticipated that "page wide" print heads containing over 2000 nozzles will be commercially available in the near future.

It has been found that circulating ink through the print head when printing and when not printing has a beneficial affect on the droplet characteristics since the temperature may be controlled by a heat exchanger positioned outside the head.

A further improvement taught in WO00/38928 is to continually pass ink through the ejection chambers. This improves the reliability of the print head by, at high enough flow-rates, reducing the possibility of air or dirt lodging in the nozzle and continually supplying fresh ink to the ejection chambers.

Because of the size of these large "page wide" print heads a large amount of ink is ejected from the heads when printing full black, i.e. when all the ejection chambers are printing at their maximum rate. It is proposed in print heads of the prior art that a flow rate of around ten times the maximum printing rate is used in order to help flush dirt out of the print head and maintain the head at a constant temperature.

Each nozzle should be at a similar pressure, preferably just below atmospheric, to minimise variations in ejection characteristics along the length of the print head.

Ink is supplied to the ejection chambers from elongate inlet and outlet manifolds that extend the length of the array and the pressure drop along the manifolds is a function of the circulation rate, manifold size and ink characteristics.

To maintain a constant pressure at each nozzle it is necessary, in view of the large flow of ink through the head, to provide inlet and outlet manifolds having large hydraulic diameters.

Print heads typically have nozzles arranged in linear arrays and are often grouped together in a printing machine such that the linear arrays of each print head lie parallel. In this arrangement multicolour printing is possible from a single pass of the paper under the print heads. A variation in the movement of the paper has one of the largest effects on drop landing position of droplets ejected from a print head possibly giving rise to visible defects in the printed image.

The effects of the variation in substrate movement can be reduced by locating the print heads close together. However, the large hydraulic diameters of the inlet and outlet manifolds often preclude this.

Ink is an expensive commodity and where the ink is a high value fluid such as, for example, biological fluid or fluid used to manufacture electronic component, the volume of ejection fluid contained within the large manifold may be prohibitive to the economic validity of the print head.

It is one object of the present invention to seek to provide smaller and more compact manifolds.

The large manifolds hold a large volume of ink which prohibits the use of a print head on a scanning carriage as movement of the head initiates "sloshing" of the ink in the manifolds. The high volume of ink also adds to the mass of the print head and consequentially the cost of the scanning carriage.

It is an object of the present invention to seek to provide a scanning print head with a circulating ink supply.

It is a further object of the present invention to seek to provide improved ink flow within an ink jet print head.

It is a further object of the present invention to seek to provide an improved pressure control and pressure distribution at the orifices of an ink jet print head.

According to one aspect of the present invention there is provided a droplet deposition apparatus comprising: a fluid chamber communicating with an orifice for droplet ejection, means for controlling the pressure of the fluid in said chamber, an inlet manifold and an outlet manifold each having a pressure drop along their length, a supply means for allowing passage of fluid to said chamber from said inlet manifold, a removal means for allowing passage of fluid from said chamber to said outlet manifold, wherein the pressure drop across said supply means or said removal means is greater than the total pressure drop along the length of said inlet manifold or said outlet manifold.

Actuators, capable of pressurising the fluid thereby ejecting a droplet from the nozzle may be located in the fluid chamber. Alternately, a row of ejection chambers comprising the actuators may be provided in communication between the fluid chamber and the orifice. In a preferred embodiment the ejection chambers divide the fluid chamber into two separate chambers hereinafter called, where appropriate, the inlet plenum chamber and the outlet plenum chamber. The inlet plenum chamber is positioned upstream of the ejection chambers and between the supply means and the ejection chambers. The outlet plenum chamber is positioned downstream of the ejection chambers and between the removal means and the ejection chambers. There is provided fluid

communication between the inlet plenum chamber and the outlet plenum chamber through the ejection chambers.

The actuators may be, for example electromechanical, in that applying an electric field causes deformation of a portion of the actuator, magnetic in that applying a magnetic field causes deformation of a portion of the actuator, thermal in that applying energy to the fluid produces a bubble, or any other appropriate form.

Active or non-active walls depending on the architecture may define the ejection chambers.

The means for controlling the pressure in the chamber may be indirect in that the head of pressure supplied to the inlet manifold is varied. These means, for example, may be an external pump.

In a preferred embodiment the means for controlling the pressure in the chamber are direct in that a tube or port open to a pressure source, vacuum source or to atmosphere connects directly with the chamber. Other means such as a diaphragm forming part of the chamber are possible. Means that vary the pressure drop across the supply means or removal means may also be used to control the pressure in the chamber. In a particularly preferred embodiment, the means for controlling the pressure in the pressure chamber comprise a Wheatstone bridge pressure control as described in WO 03/022586 and incorporated herein by reference.

This form of pressure control is of particular use where the fluid chamber is divided into an inlet plenum chamber and an outlet plenum chamber by ejection chambers located between the two with an orifice positioned within the ejection chamber.

The Wheatstone bridge comprises four arms having a resistance to the fluid, the four arms are: a) the ejection chamber between the inlet plenum chamber and the orifice, b) the ejection chamber between the orifice and outlet plenum chamber, c) a passageway provided between the outlet plenum chamber and an external pressure reference point and d) a passageway provided between the external pressure reference point and the inlet plenum chamber.

There may be a flow of fluid around the arm of the Wheatstone bridge that comprises the pressure reference point that is of the order 1 times the total flowrate of ink ejected through the orifices. Other values, greater or lower, may be appropriate. In some circumstances there may be a zero flow-rate around this point.

The supply means may form one wall of the chamber, may be located within the chamber or may be located remote from the chamber in, or part of an ancillary chamber. The supply means preferably supply ink along the length of the chamber and the ink exiting the supply means is preferably at the same pressure along the length of the supply means. This beneficially provides a constant pressure along the length of the chamber.

The flowrate fluid is supplied to the chamber through the supply means is preferably greater than the flowrate at which fluid can be ejected through the orifices. Preferably this rate is of the order 10 times the maximum ejection rate though other rates greater and less than this figure will be appropriate depending on, for example, the amount of dirt or air in the ink or, where the ink is used to cool a drive circuit, the amount of heat dissipated by the drive circuit.

The supply means are preferably formed of a material or a structure that provides a high pressure drop whilst allowing fluid to pass between the inlet manifold and the chamber. In one embodiment the material may be one that is porous for example, but not limited to, a sintered ceramic or metal, woven or meshed fibre

or etched, cut or electroformed structures. Preferably the pore sizes will be of a sufficient size such that a filtering function is provided to the fluid. The pore sizes will preferably be below 50µm and more preferably below 25µm.

In a preferred embodiment the pressure drop across the supply means varies along its length. This may be achieved by, for example, varying the pore size or cross-sectional area of the supply means.

In a further embodiment the pressure drop is provided by a structure formed by, for example, laminated plates that provides narrow channels. The cross-sectional area of the channels may be modified during operation by, for example, heating or cooling the area around the channel or by depositing within the channel a material that varies its volume of shape under application of a magnetic field. A piezoelectric ceramic is an example of a suitable material.

The pressure of fluid in the supply manifold is greater than the pressure of the fluid in the fluid chamber, there being a significant pressure drop across the supply means. The pressure drop across the supply means is greater than the total pressure drop along the length of the manifold and preferably significantly greater.

The removal means are preferably formed of a material or a structure that provides a high pressure drop whilst allowing fluid to pass between the chamber and the outlet manifold. In one embodiment the material may be one that is porous for example, but not limited to, a sintered ceramic or metal, woven or meshed fibre or etched, cut or electroformed structures. Preferably the pore sizes will be of a sufficient size such that a filtering function is provided to the fluid. The pore sizes will preferably be below 50µm and more preferably below 25µm.

In a preferred embodiment the pressure drop across the removal means varies along its length. This may be achieved by, for example, varying the pore size or cross-sectional area of the supply means.

In a further embodiment the pressure drop is provided by a structure formed by, for example, laminated plates that provides narrow channels. The cross-sectional area of the channels may be modified during operation by, for example, heating or cooling the area around the channel or by depositing within the channel a material that varies its volume of shape under application of a magnetic field. A piezoelectric ceramic is an example of a suitable material.

The removal means and supply means are preferably formed of the same material and, in one embodiment may be a single component; a portion or portions of the component providing the supply function and a portion or portions of the component providing the remove function. In an alternative embodiment they are two separate components.

The pressure of fluid in the outlet manifold is lower than the pressure of the fluid in the fluid chamber, there being a significant pressure drop across the removal means. The pressure drop across the removal means is greater than the pressure drop along the length of the manifold and preferably significantly greater.

The pressure drop across the supply means and / or the removal means is preferably greater than the pressure drop across the fluid chamber and preferably significantly greater.

The inlet or outlet manifolds may, where the supply means and / or removal means are tubular, be the bores within the tubes. Alternately, they may be chambers isolated from the fluid chamber by the supply and removal means.

The inlet manifold is preferably supplied with fluid from an external circuit. For example, a pump or other means such as gravity may be used to provide the required head of pressure in the ink supply manifold.

According to a second aspect of the present invention there is provided a droplet deposition apparatus comprising an inlet manifold, an outlet manifold and a fluid chamber in communication with at least one orifice; said fluid chamber separated from said inlet manifold and said outlet manifold by at least one element providing a resistance to a fluid and allowing said fluid to pass therethrough; there being a flow of said fluid between said inlet manifold and said outlet manifold through said chamber, and pressure control means communicating directly with said fluid chamber for controlling the pressure at said orifice.

The print head may be mounted on a scanning carriage

According to a third aspect there is provided a droplet deposition apparatus comprising: a print head comprising an inlet manifold, an outlet manifold and a fluid chamber in communication with at least one orifice
Said fluid chamber separated from said inlet manifold and said outlet manifold by at least one element providing a resistance to a fluid and allowing said fluid to pass therethrough; and there being a flow of fluid between said inlet manifold and said outlet manifold through said chamber,
Wherein the pressure drop across the said at least one element is the dominant pressure drop in the print head.

Said apparatus further comprising pressure control means communicating directly with said fluid chamber for controlling the pressure at said orifice,

The inlet manifold, porous barrier, fluid chamber and ejection chambers may be formed from a single etched sheet.

According to a fourth aspect of the present invention there is provided a droplet deposition apparatus comprising a chamber in communication with an ejection nozzle, with supply means extending the substantially the length of the chamber for supplying fluid to said chamber uniformly along substantially its length, said chamber further comprising removal means extending substantially along its length for removing fluid from said chamber along substantially its length, wherein a body of circulating fluid passes through said chamber between said supply means and said removal means

The supply means and removal means may be formed of a high pressure drop filter material or sintered plate which forms one wall of the chamber.

The supply means and removal means may be located in an antechamber remote from said chamber.

Any one of the pressure control means described above may be provided in communication with the chamber thereby controlling the pressure.

The invention described herein also resides in methods.

According to a fifth aspect there is provided a method of supplying a fluid to an orifice of a droplet deposition apparatus having a line of orifices and an ink supply manifold extending parallel to said orifices, said method comprising the steps of: supplying ink in said manifold said ink flowing substantially parallel to said line of orifices and in a volume in excess of that which may be ejected from the orifices, and causing said ink to flow through at least one restrictive element and into a fluid chamber wherein the flow of fluid within said fluid chamber is substantially not parallel to said line of orifices

The invention will now be described, by way of example only, with reference to the following drawings in which:

Figure 1 is an ink supply manifold according to the prior art

Figure 2 depicts a through flow ink jet printhead according to the prior art.

Figure 3 is an ink supply circuit according to the prior art.

Figure 4 is an ink supply according to one embodiment of the present invention

Figure 5 is an ink supply according to a second embodiment of the present invention

Figure 6 is an ink circulation system according to the present invention for supplying ink to a print head.

Figure 7 is a further ink circulation system according to the present invention for supplying ink to a print head.

Figure 8 is an ink supply manifold according to the present invention.

Figure 9 is an end shooter print head according to the present invention.

Figure 10(a) to (g) depict a plurality of layers which when laminated form a print head according to the present invention.

Figure 11 depicts a plurality of the modules of figure 10 mounted to an ink supply support.

Figure 1 depicts an ink supply support of an inkjet printer according to the prior art. A central inlet manifold 920 has ink flowing in one direction (depicted as 915) along the length of the array. Conduits 930 formed in the top of the array and in a

base plate 970 allow the ink to reach the pressure chambers (not shown) Ink is ejected through nozzles and the un-ejected ink is circulated to the outlet manifold 910 via two ports 940 and 950. Ink in the outlet manifold flows in the opposite direction 935 in order to minimise any thermal gradient over the length of the print head.

A positive pressure relative to atmospheric is established at the entrance to the inlet manifold by a pump and a negative pressure relative to atmospheric is established at the exit of the outlet manifold.

As in any hydraulic system there are pressure gradients and pressure drops such as along the manifolds, through the holes 930, 940 and 950 in the supply support and the ports provided in base plate 970.

The manifolds within the print head need to be large as the inlet carries (typically) 10 times the maximum printing flowrate, while the outlet manifold carries between 9 and 10 times the maximum printing flowrate. Uniformity of the pressure at the nozzles is maintained by ensuring the pressure difference between the entrance of the inlet manifold and exit of the outlet manifold is overwhelmingly effected by the ejection chambers.

It is necessary that the manifolds 920, 910 and the ports 930,940 and 950 are large to minimise both the pressure drop through the ports 930, 940 and 950 and along the inlet and outlet manifolds.

Figure 2 depicts the structure of the actuators and flow path in greater detail. Ports 974 provided in the base plate 970 to supply ink to a fluid chamber which is divided into three sections 980, 980' and 980" by the ejection chambers 982 formed in two rows of PZT 110a, 110b. The outlet ports 972 allow the ink to flow from the plenum chamber back to the supply support.

Channels are sawn in the piezoelectric element 110a, 110b to provide the ejection chambers. Electrical connection tracks (not shown) are formed on the substrate 970 and connect chips (not shown) to electrodes (not shown) on either side of the walls bounding channels. The piezoelectric walls are poled such that upon activation of a field between the electrodes formed on either side of the walls, they deflect in shear mode to eject an ink droplet from a nozzle 984 formed on a cover plate 986 bonded to the tops of the walls.

A particularly elegant ink supply for a print head having a single row of ejection chambers is depicted in Figure 3. A single row print head 68 is shown as two resistors 58,56 either side of the nozzle 30. The inlet manifold 920, ports 974 and one half of an ejection chamber of Figure 2 constitute the resistor 58 upstream of the nozzle. The outlet manifold 910, ports 972 and one half of the ejection chamber of Figure 2 constitute the resistor 56 downstream of the nozzle. If the nozzle was not located midway along the ejection chambers then the contribution the ejection chamber constitutes to the value of the resistors 56 and 58 would vary.

A pump 52 supplies both the print head 68 and a pressure reference arm in what is analogous to an electrical Wheatstone bridge circuit. A filter 66 provides a cleaning function for the ink. The resistor 60 and the resistor 62 are matched to resistor 58 and 56 respectively and preferably all four resistors are substantially identical. The pressure at the nozzle can be controlled by raising or lowering the height of a small reservoir 64 that communicates with the pressure reference point "A". The flow of ink through the print head is greater than the flow of ink through the reference arm. The reservoir 54 provides fluid to the circuit to make up that which is lost through evaporation or from the nozzles by ejection.

Figure 4 depicts one embodiment of the present invention. The base plate 970 is provided by a porous, sintered ceramic.

The fluid chamber comprises actuators 984 mounted to a common support located on the base plate. The support may comprise all the necessary electrical connectors. Each actuator is not separated from an adjacent actuator by walls. The flow of ink across the actuators is still substantially in the direction of the arrow D.

The pores vary in size and distribution along the length thereby maintaining a constant pressure along the length of the fluid chamber inlet 980 despite any pressure drop along the length of the inlet manifold 930.

Beneficially, this allows the size of the manifold 930 to be reduced, as it is no longer necessary to maintain a constant pressure along its length and even large pressure differences along the length can be equalised by making the pressure drop across the porous support 970 high in comparison with the pressure drop along the length of the manifold.

In this embodiment, by providing an inlet and outlet manifold separated from a plenum chamber by the porous support, the flow of ink along the manifolds is converted to a flow across the chamber perpendicular to the length of the manifold.

In the architecture of Figure 4, actuators are provided atop the support 970. The actuators are heaters that provide thermal energy to the fluid and thereby cause fluid to be ejected through the nozzle (not shown). The parallel flow of fluid within the plenum chamber provides a pressure at each of the actuators, when quiescent, which is the same.

As depicted in Figure 5, the fluid chamber 980 may, however be divided into two or more separate chambers, the inlet plenum chamber 980' and the outlet plenum chamber 980" which are in fluid connection via the ejection chambers 990. These ejection chambers are positioned within the fluid chamber between

the inlet and outlet manifolds 930, 940. Blocks of PZT 110a and 110b comprise ejection channels sawn perpendicular to the length of the manifold, and parallel to the flow of ink in the chamber. Fluid circulates continuously through the channels providing a cleaning and cooling function. The walls are polarised orthogonal to the elongation of the ejection channels and electrodes provided on either side of the wall allow an electric field to pass across the wall. The field passed across the walls causes the walls to deflect into or out of the channels thereby causing a droplet of ink to be ejected.

In both of the embodiments of Figure 4 and Figure 5, and any embodiment where the fluid flows past the nozzle, the pressure at the nozzle may be controlled using an improved "Wheatstone Bridge" ink supply based on the example given in Figure 3. The improved ink supply according to the present invention is described with reference to Figure 6.

The ejection channels 990 are depicted as a resistor having a resistance R2 upstream of the nozzle and a resistance R1 downstream of the nozzle. Resitors R3 and R4 in a pressure reference arm of the ink supply balance these resistances.

A flow of ink is provided around a second circuit that consists of the print head and the inlet 930 and outlet 940 manifolds. A second pump 53 is provided that pumps ink around this circuit. Where possible, all other reference numerals are identical with Figure 3.

The pressures and flowrates within the system can be depicted as follows: the pressures Pi(x) along the length of the inlet manifold 930, Pf(x) in the inlet plenum chamber 980', Pn(x) at the nozzles 30, Pr(x) in the outlet plenum chamber 980", Po(x) within the outlet manifold 940, volume flowrates Vi(x) in the inlet manifold, Vf(x) in the inlet plenum chamber, Vr(x) in the outlet plenum chamber and Vo(x) in the outlet manifold.

The pressures and flowrates are determined by the pressure Pc imposed by the small reservoir 64, the pump flowrate/pressure characteristics (V1, V2) and hydraulic resistances: s, the resistance through the channels, R through the porous element and the external resistors Q. The volume flowrate per unit length v(x) printed at each point along the array is constant in time. In this situation the porous element is a common component providing both the supply means and removal means function and therefore R is substantially the same. It is of course possible that the resistances for both are different.

When the print head is not printing (v=0), the pressure at the nozzles is Pc, determined by the small reservoir and typically slightly negative. When the Print head is printing uniformly, $v \neq 0$, the pressure at all the nozzles is lowered by an amount equal to :

$$s.v.[QL/(2s)+1+s/(2LQ)] / [1+s/(LQ)]$$

This figure is independent of R such that the permeability of the porous barrier may be limited during use, through blockages etc. without producing problems provided the pumps can cope with the additional pressure drop.

The nozzle pressure drop on printing varies with Q as follows: if $Q \ll s/L$, the pressure drop is ½ sv. If $Q \gg s/L$, the pressure drop is vQL/2 and has been found to be excessive. If Q=s/L, the nozzle printing drop is an acceptable sv.

Where $Q \ll s/L$, the flowrate of V1 has to be very large to avoid a negative flowrate in the chamber. The negative flowrate is caused by flow from the second pump circulating through the reference arm.

Where V2 is substantial, around ten times the maximum printing flowrate, the system can withstand a considerable pressure drop along the length of the inlet manifold.

Where Q=s/L, the flowrates in the system are (V1-vL+V2)/2 through the restrictors; (V1+vL+V2)/2 through the channels; V2 in the inlet manifold; (V1+vL-V2)/2 in the inlet plenum chamber and (V1-V2)/2 in the outlet plenum chamber. If V1=V2=10vL then the desired through flowrate in the channels is achieved but the flowrates into and out of the plenum chambers (other than through the channels) is small. The plenum chambers, and inlet and outlet manifolds may be small without presenting an unwanted pressure drop.

In Figure 7, the dual pumps is replaced by a single pump where additional resistances R5, R6 are provided which act, with R3 and R4, as a bridge and control the pressures at the nozzles. R5 is of the same order as the resistance of the porous wall 970.

The volume flowrate of the pump is about 20 times the maximum printing flowrate. Half goes through R5, R3 and then through R4 and R6, the other half through the porous element within the print head. There is very little flow out of or into the fluid chamber and hence no pressure drop along the inside of the fluid chamber.

In a further embodiment, described in Figure 8, the porous element 970 does not form one wall of the plenum chamber but is positioned in an antechamber 931, 941 which is in communication with the fluid chamber 982 or divided plenum chambers 980' and 980"

The porous element is a tube with a bore. The bore forms the inlet manifold 930 and the fluid passes through the element 970 into the inlet antechamber 931.

Ports 972 formed in the base plate provide fluid communication between the plenum chamber 980' and the inlet antechamber 931.

A Wheatstone bridge, as described above, may be used to control the pressure at the nozzle. Because the flow around the pressure reference arm of the Wheatstone bridge is so small, in some circumstances it is possible to replace this structure with a simple connection to a positive or negative pressure source. In certain embodiments this may be achieved by a single outlet from the fluid chamber as opposed to two outlets from the plenum chambers as required by a Wheatstone bridge arrangement.

The above embodiments all positioned the nozzles and ejection chambers in the fluid chamber and between the ink inlet and the ink outlet. The ability to provide a low pressure drop, small manifolds and ink circulation is, however also useful for print heads commonly known as end-shooters.

End-shooter print heads do not circulate ink through the channels but rather have chambers with a single ink inlet and a nozzle positioned in an end wall. Figure 9 depicts such a structure.

The inlet manifold 930 extends the length of the printhead and supplies ink to the fluid chamber 980. An outlet manifold 940 removes the ink from the plenum chamber and permits constant circulation. An end-shooter ejection chamber 990 is provided to one side of and is supplied with ink from the fluid chamber. A cover 992 may be used to close both the top of the ejection chamber and the top of the fluid chamber. Any of the above pressure control mechanisms may be used to control the pressure within the fluid chamber.

As depicted in Figure 10, the structure may be formed from a plurality of laminated plates in a modular form. Each module has a number of nozzles 994 arranged in an array. The nozzles communicate with a pressure chamber 998

formed within a second plate. A number of ports 997, 998 communicate between the pressure chambers and the inlet and outlet antechambers 931, 941.

Connectors 961,963 are provided to each of the inlet plenum chambers and outlet chambers which communicate to the external pressure controller. The porous barrier 970 is laminated between the plate that forms the plenum chambers and a further plate that forms the manifolds.

Ports connecting with the inlet and outlet plenum chambers are provided both in the porous barrier plate and the manifold plate. A cover plate 965 with four ports closes the manifolds. The materials of the plates are Nilo 42 which has a coefficient of thermal expansion close to that of PZT.

The modules may be used as they are or mounted to an ink supply support. The support comprises four conduits 1000, 1001, 1002, 1003 which communicate with the inlet manifold, inlet plenum chamber, outlet plenum chamber and outlet manifold respectively. The modules are removably mounted to the support as depicted in Figure 11.

Each feature disclosed in this specification (which term includes the claims) and / or shown in the drawings may be incorporated in the invention independent of or in combination with other disclosed and / or illustrated features.

Claims

1. Droplet deposition apparatus comprising: a fluid chamber communicating with an orifice for droplet ejection, means for controlling the pressure of the fluid in said chamber, an inlet manifold and an outlet manifold each having a pressure drop along their length, a supply means for allowing passage of fluid to said chamber from said inlet manifold, a removal means for allowing passage of fluid from said chamber to said outlet manifold, wherein the pressure drop across said supply means or said removal means is greater than the total pressure drop along the length of said inlet manifold or said outlet manifold.

2. Apparatus according to Claim 1, wherein a plurality of orifices communicate with said fluid chamber.

3. Apparatus according to Claim 2, wherein said plurality of orifices are arranged as an elongate array.

3. Apparatus according to Claim 3, wherein either or both of said inlet and outlet manifolds extend parallel to said elongate array.

5. Apparatus according to Claim 2, further comprising an array of ejection chambers within said fluid chamber, each ejection chamber communicating with a respective orifice.

6. Apparatus according to Claim 5, wherein said fluid chamber is divided into an inlet chamber and an outlet chamber by said array of ejection chambers, there being a flow of fluid between said inlet and said outlet chamber through said ejection chambers.

7. Apparatus according to Claim 6, wherein said orifice is located mid way along an ejection chamber.

8. Apparatus according to any preceding claim, wherein said supply means and / or said removal means comprise a porous element.

9. Apparatus according to Claim 8, wherein said porous element is flat.

10. Apparatus according to Claim 8, wherein said porous element is tubular.

11. Apparatus according to any one of Claim 8 to Claim 10, wherein said porous element is a sintered material

12. Apparatus according to any one of Claim 8 to Claim 10, wherein said porous element is a mesh.

13. Apparatus according to any preceding claim, wherein said means for controlling pressure is a pump.

14. Apparatus according to any one of Claim 1 to Claim 12, wherein said means for controlling pressure is a tube open to atmosphere.

15. Apparatus according to any one of Claim 1 to Claim 12, wherein said means for controlling pressure is a wheatstone bridge.

16. Droplet deposition apparatus comprising an inlet manifold, an outlet manifold and a fluid chamber in communication with at least one orifice; said fluid chamber separated from said inlet manifold and said outlet manifold by at least one element providing a resistance to a fluid and allowing said fluid to pass therethrough; there being a flow of said fluid between said inlet manifold and said outlet manifold through said chamber, and pressure control means

communicating directly with said fluid chamber for controlling the pressure at said orifice.

17. A droplet deposition apparatus comprising: a print head comprising an inlet manifold, an outlet manifold and a fluid chamber in communication with at least one orifice, said fluid chamber separated from said inlet manifold and said outlet manifold by at least one porous element and there being a flow of fluid between said inlet manifold and said outlet manifold through said chamber, wherein the pressure drop across the said at least one porous element is the dominant pressure drop in the print head.

18. A droplet deposition apparatus comprising a chamber in communication with an ejection nozzle, with supply means extending the substantially the length of the chamber for supplying fluid to said chamber uniformly along substantially its length, said chamber further comprising removal means extending substantially along its length for removing fluid from said chamber along substantially its length, wherein a body of circulating fluid passes through said chamber between said supply means and said removal means

19. A method of supplying a fluid to an orifice of a droplet deposition apparatus having a line of orifices and an ink supply manifold extending parallel to said orifices, said method comprising the steps of:
supplying ink in said manifold said ink flowing substantially parallel to said line of orifices and in a volume in excess of that which may be ejected from the orifices, and causing said ink to flow through at least one restrictive element and into a fluid chamber wherein the flow of fluid within said fluid chamber is substantially not parallel to said line of orifices

20. A method according to Claim 19 wherein the pressure of the fluid in the plenum chamber is controlled via a port opening into said plenum chamber.

21. A method according to Claim 19 or Claim 20, further comprising the step of causing the fluid in excess of that ejected from the orifices to flow through from the plenum chamber through a porous element into an outlet manifold.

22. A method according to Claim 21, wherein ejection channels are provided within said plenum chamber, said fluid flowing through said ejection channels.

19. A method of supplying a fluid to an orifice of a droplet deposition apparatus having a line of orifices and an ink supply manifold extending parallel to said orifices, said method comprising the steps of:
supplying ink in said manifold said ink flowing substantially parallel to said line of orifices and in a volume in excess of that which may be ejected from the orifices, and causing said ink to flow through at least one restrictive element and into a fluid chamber wherein the flow of fluid through said restrictive element is substantially not parallel to said line of orifices.

23. Apparatus as substantially hereinbefore described with reference to Figures 4 to 11.

24. A method as substantially hereinbefore described with reference to Figures 4 to 11.

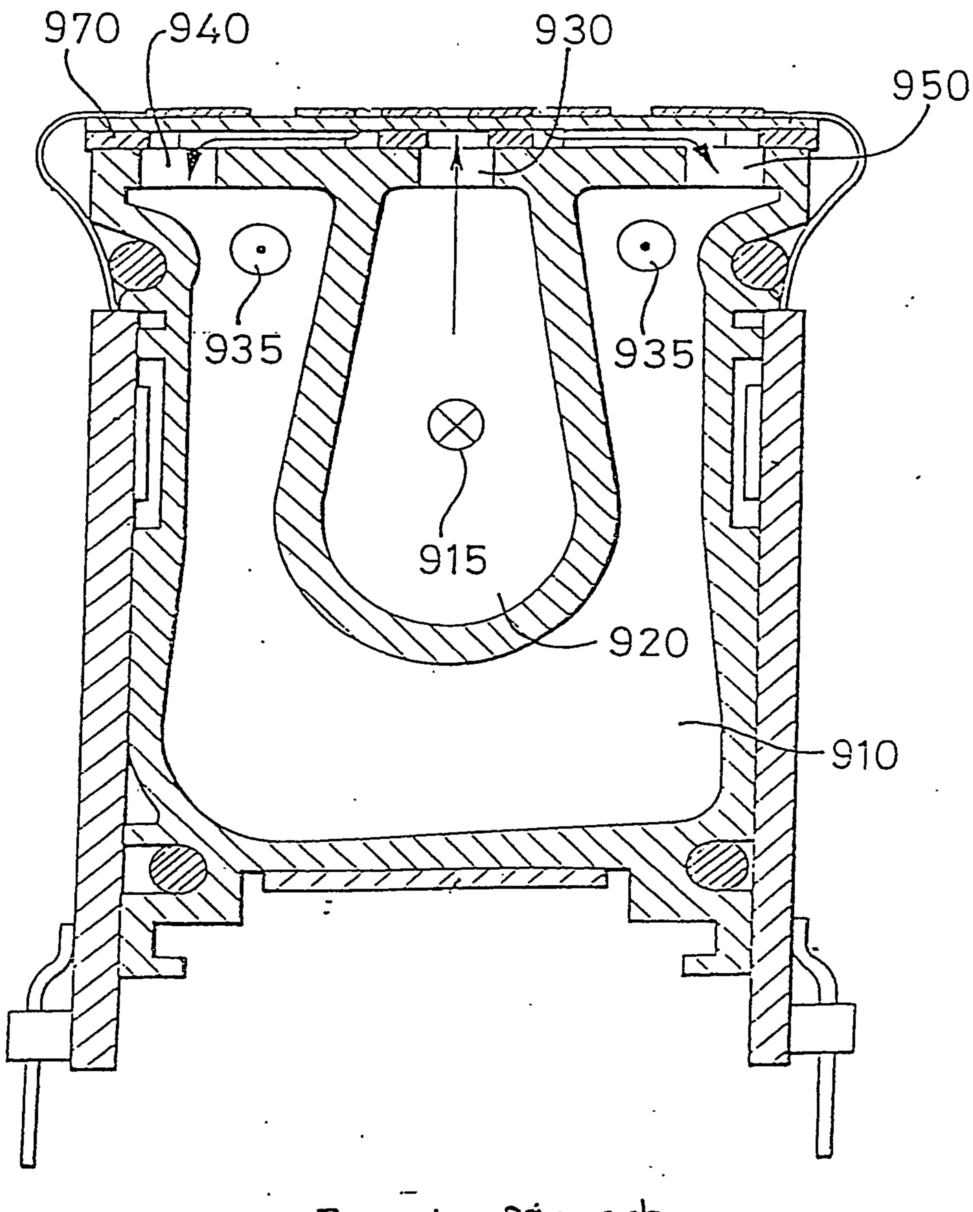


Figure 1 – prior art.

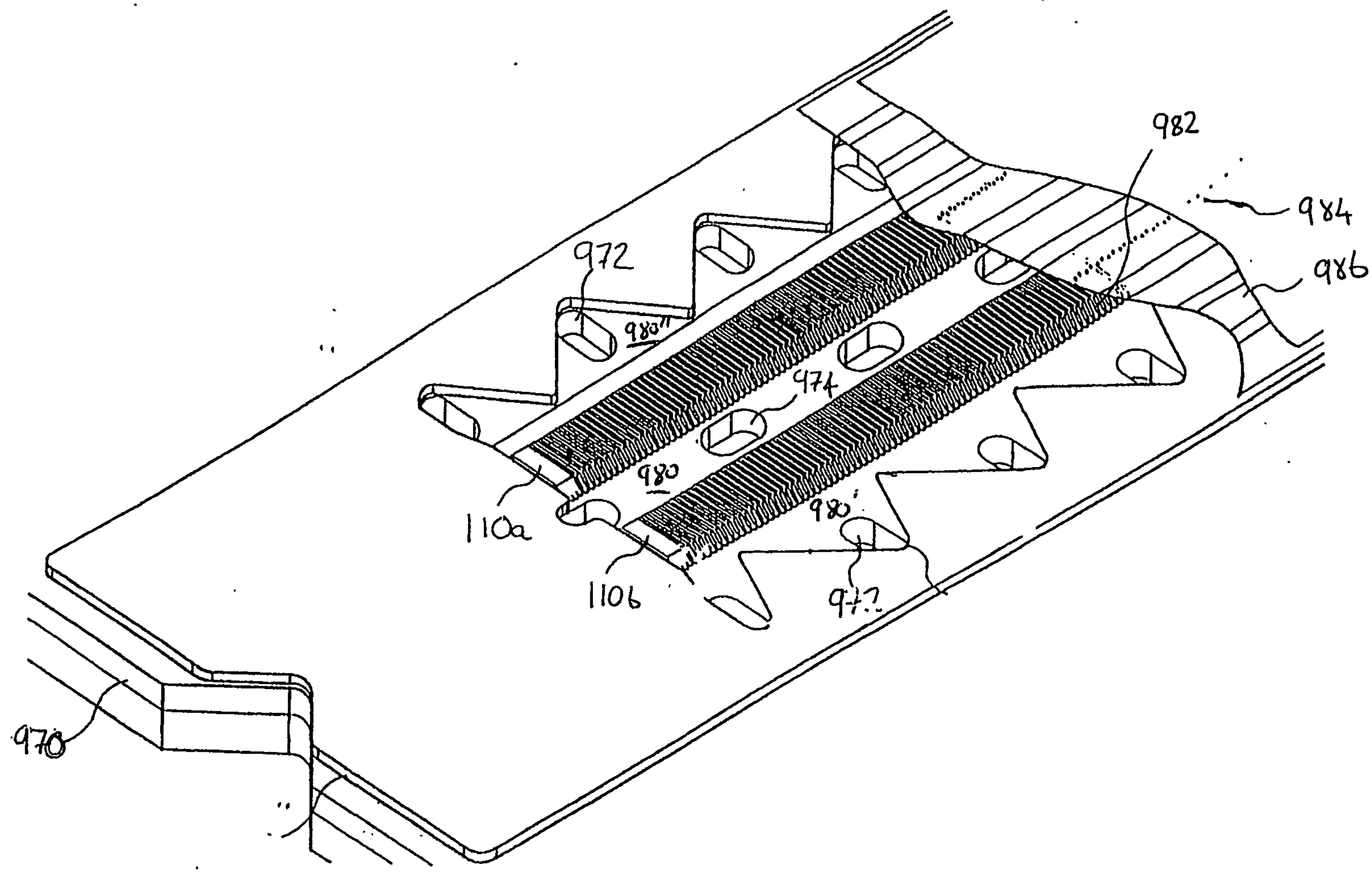


Figure 2– prior art.

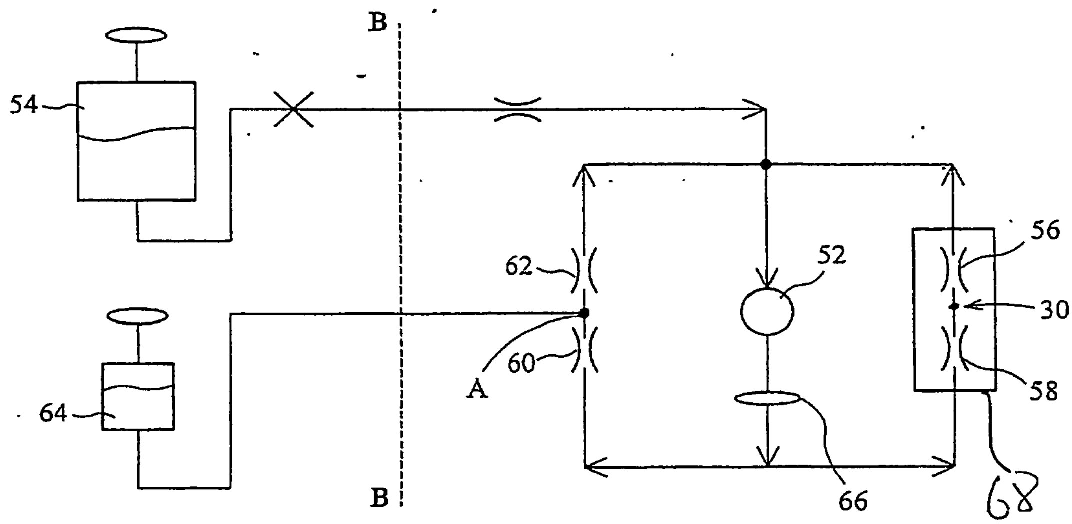


Figure 3

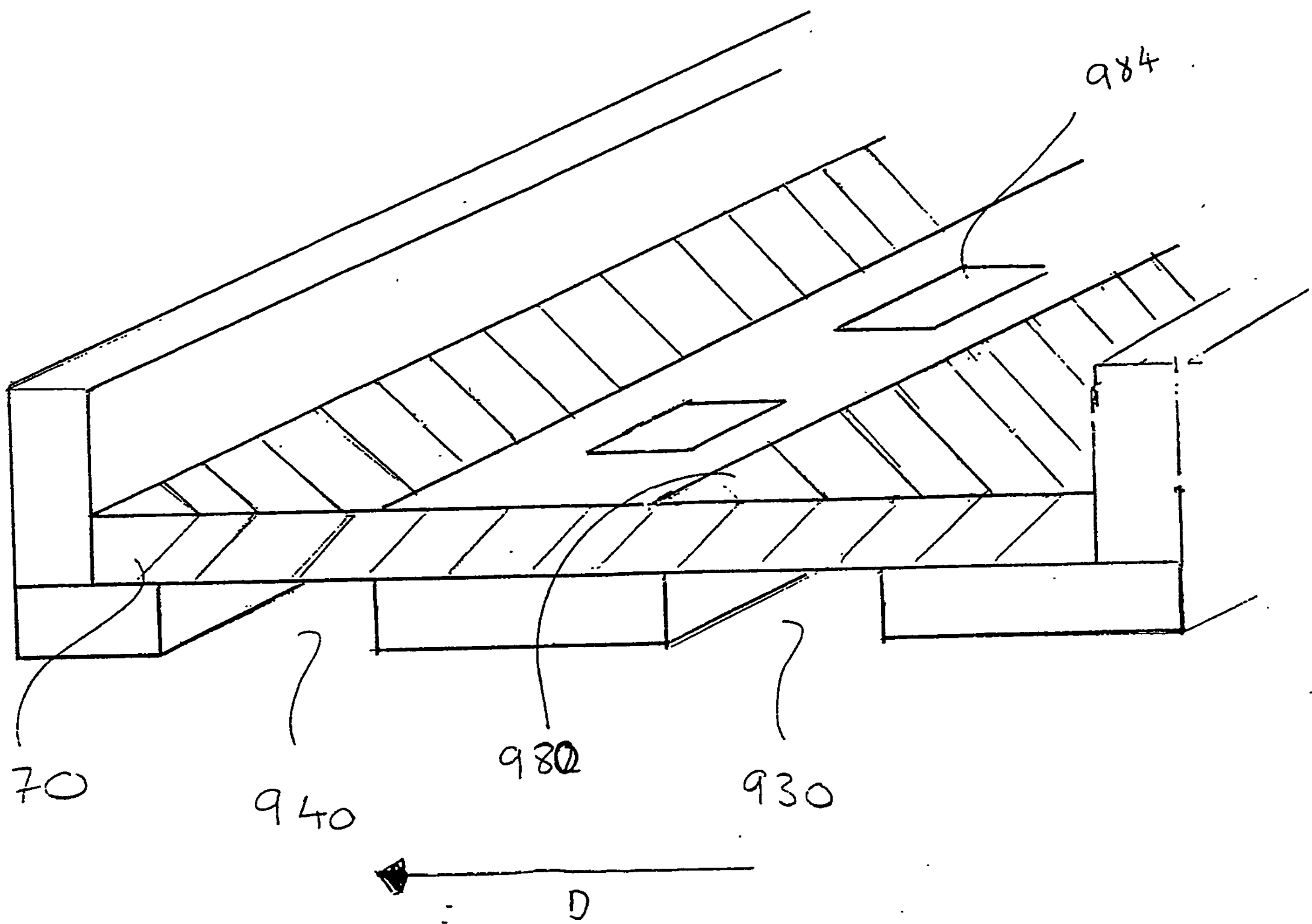


Figure 4.

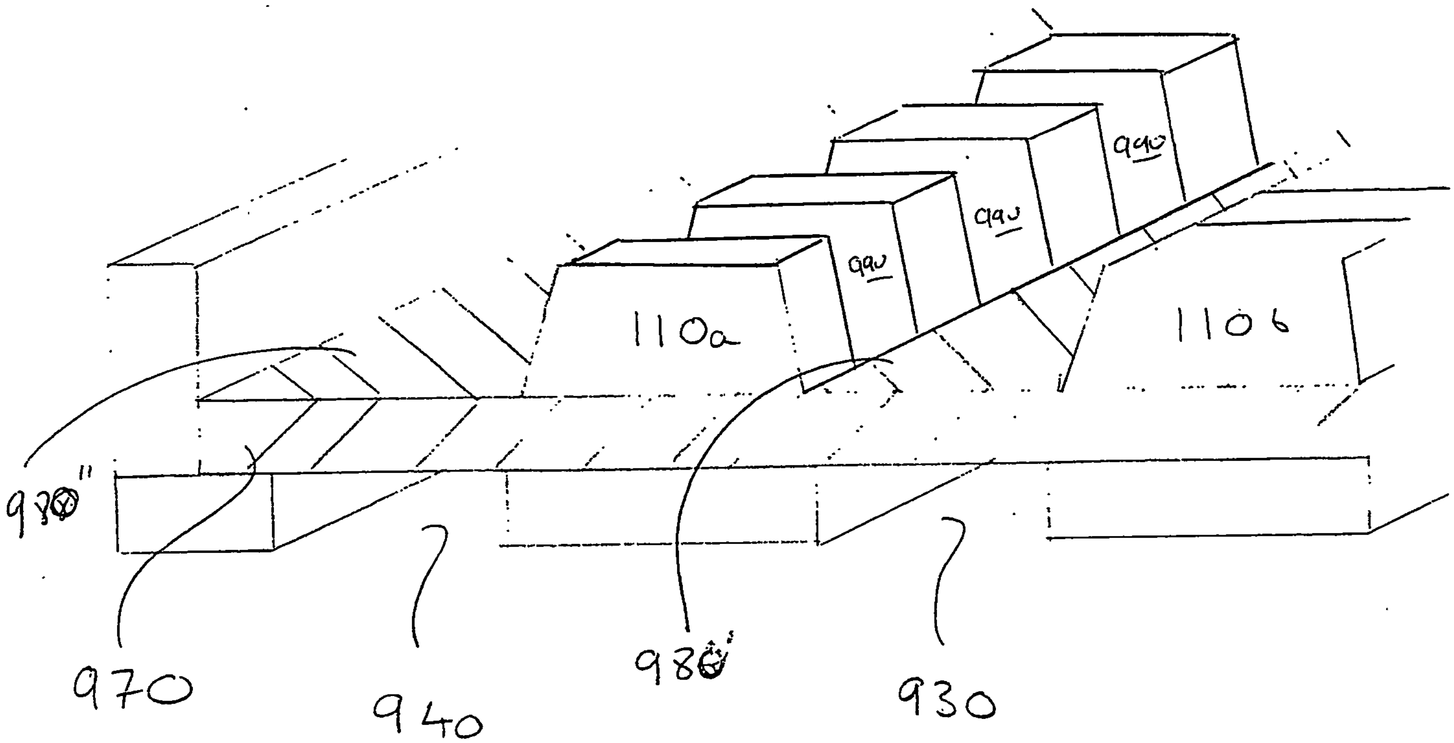


Figure 5

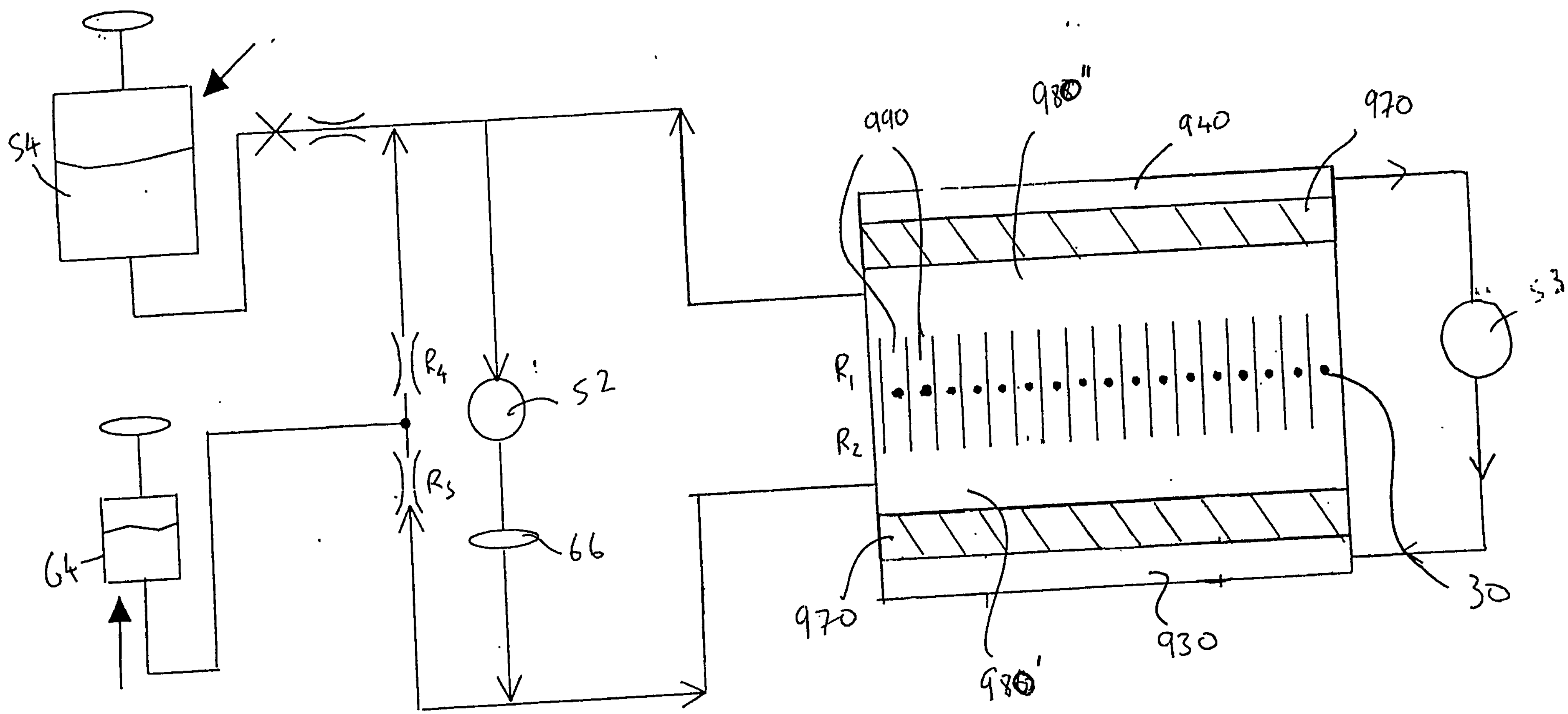


Figure 6

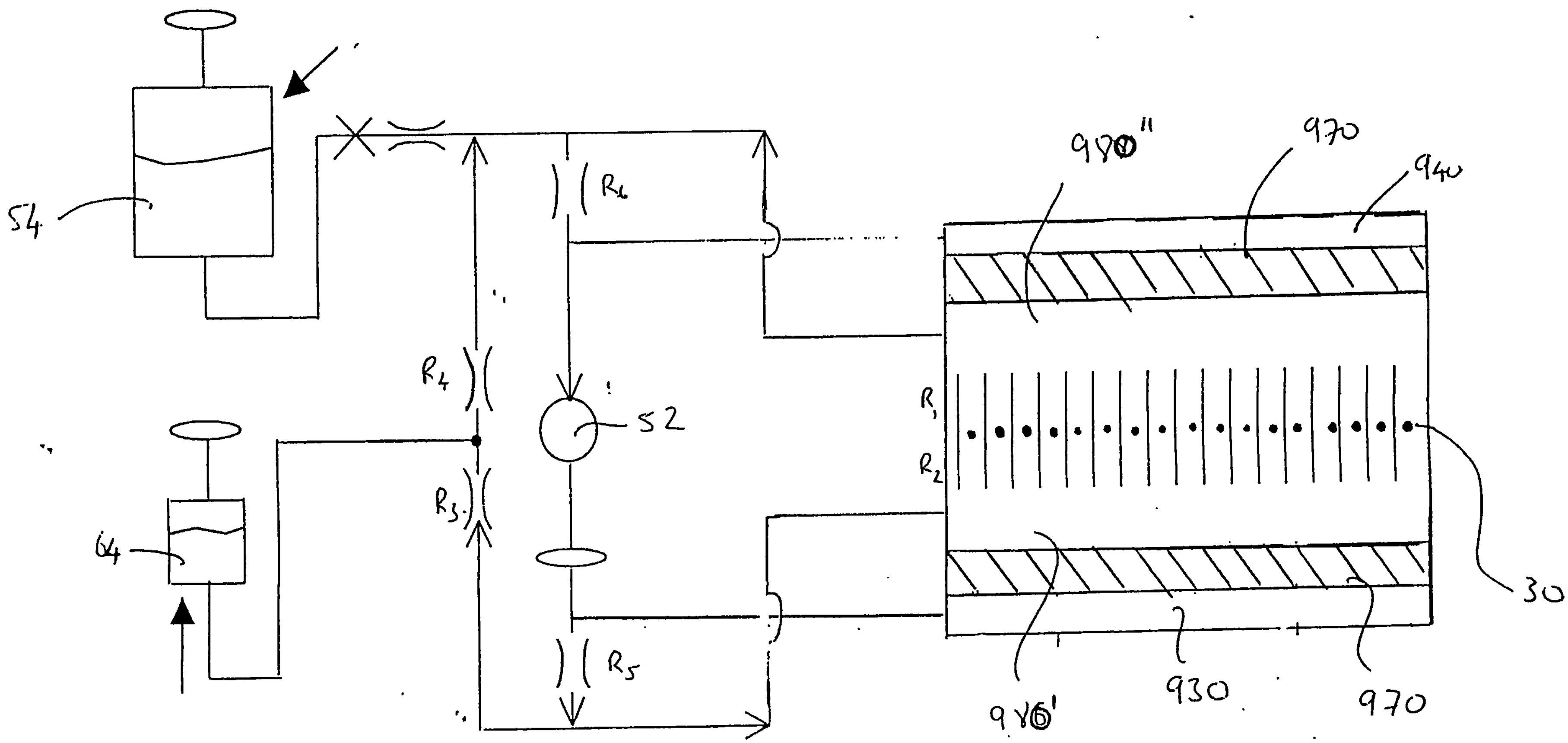


Figure 7

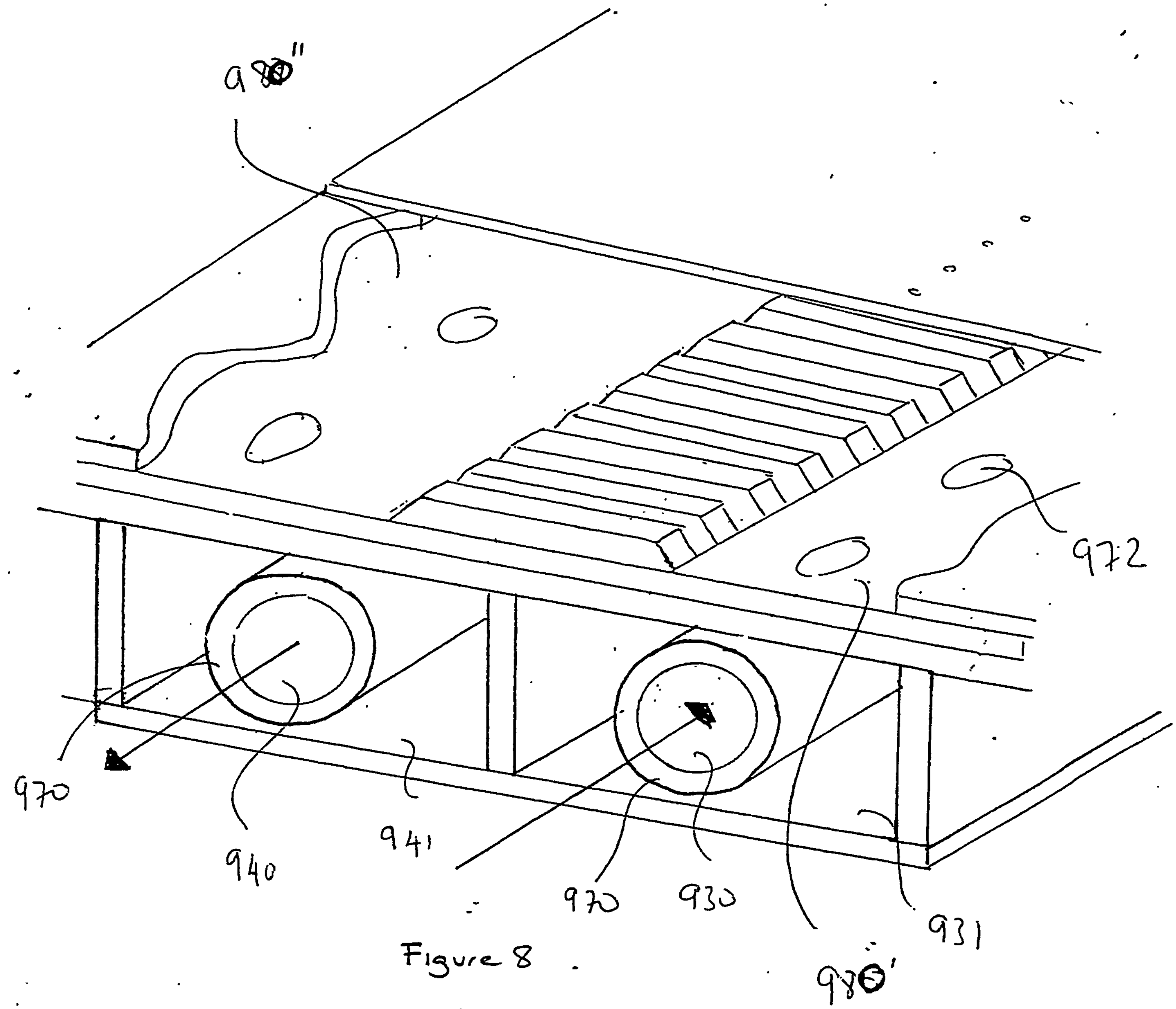


Figure 8

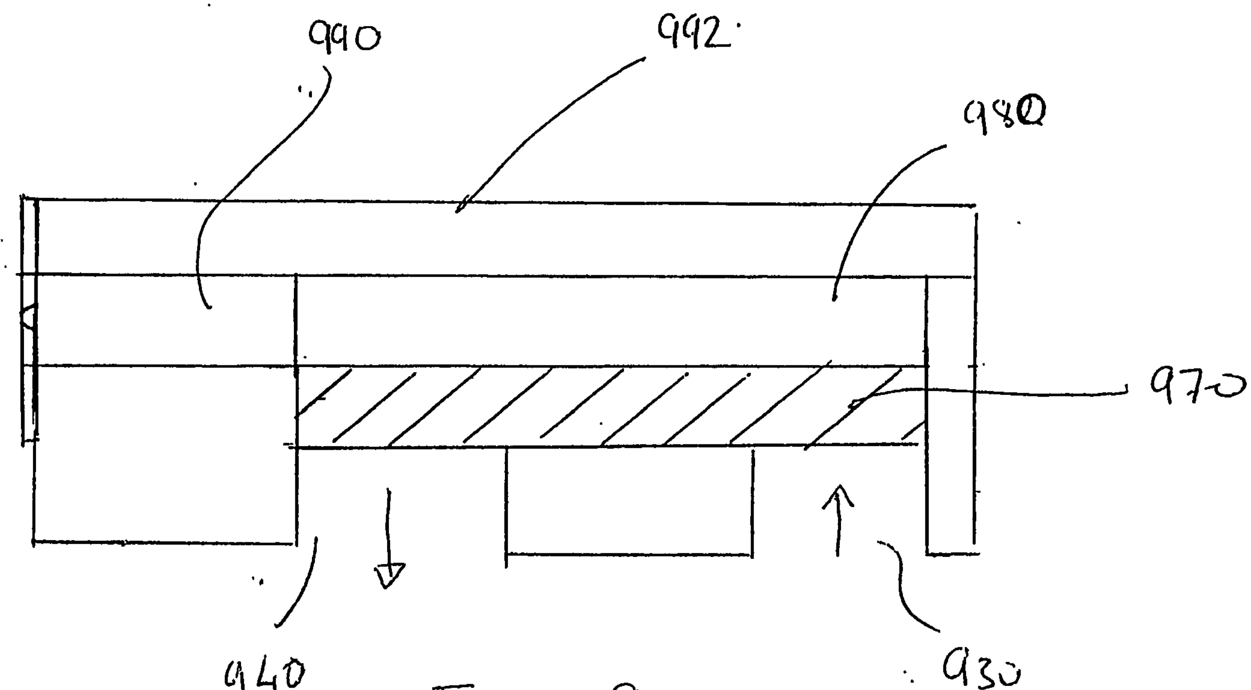
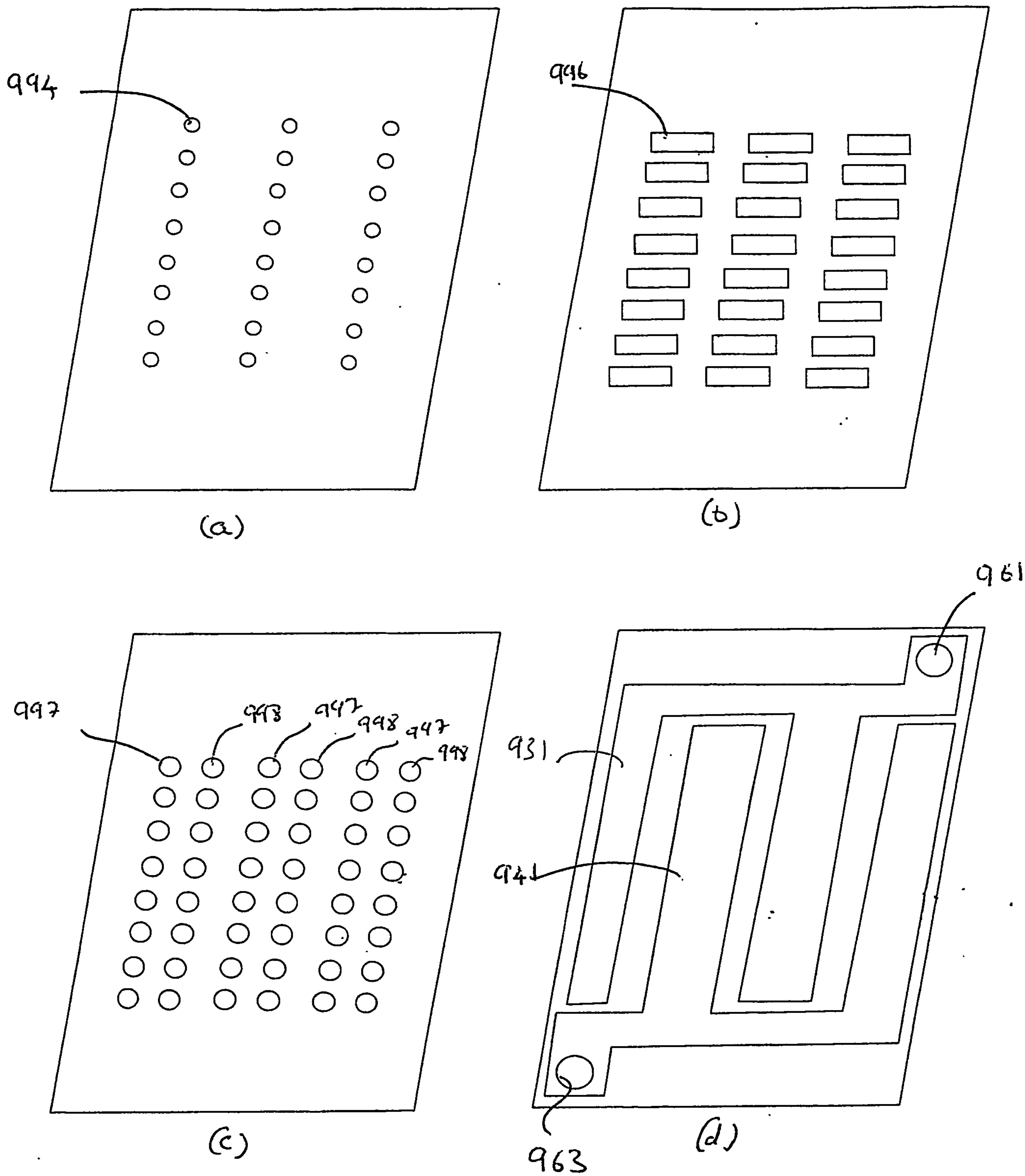


Figure 9



Figue 10

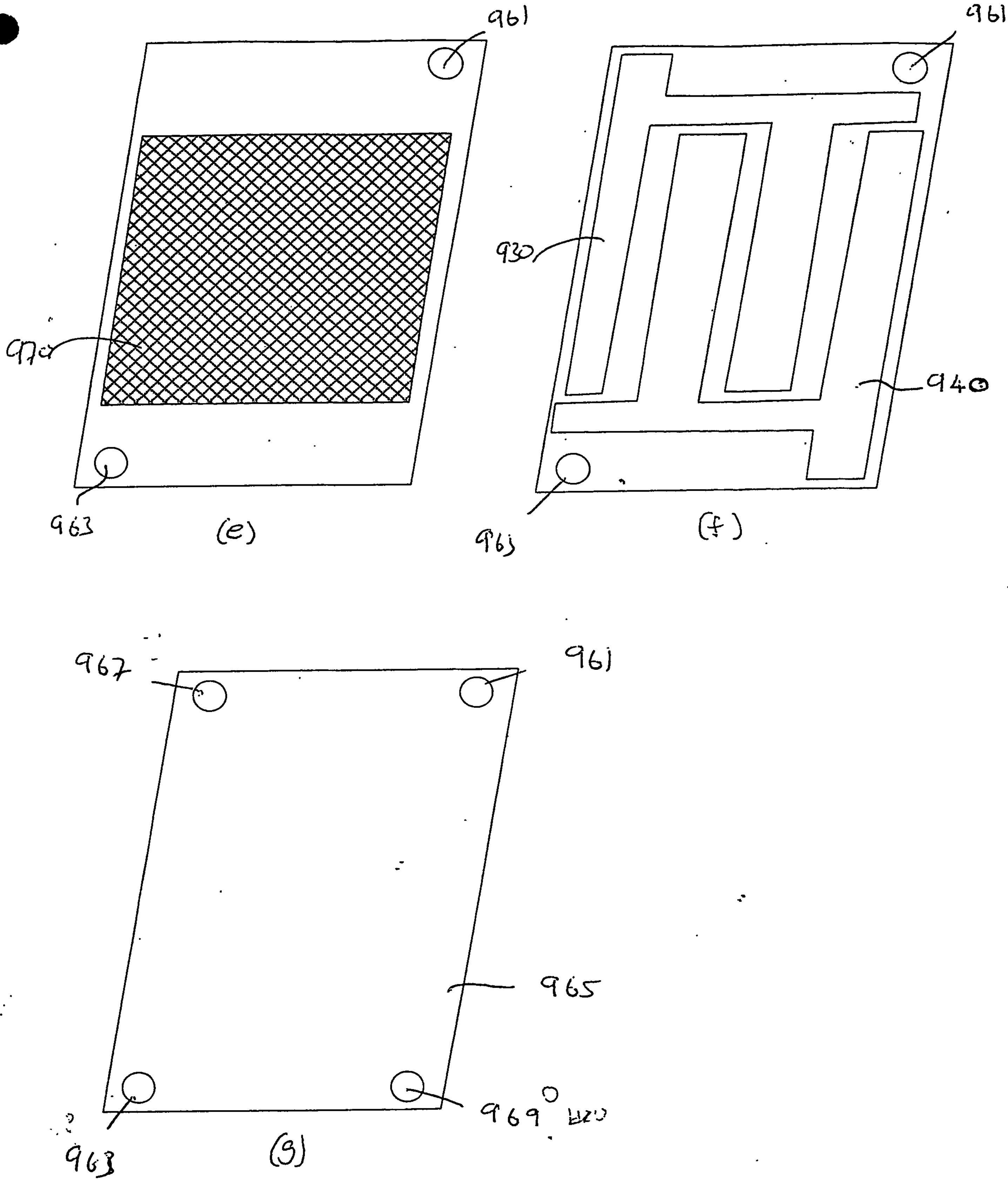


Figure 10

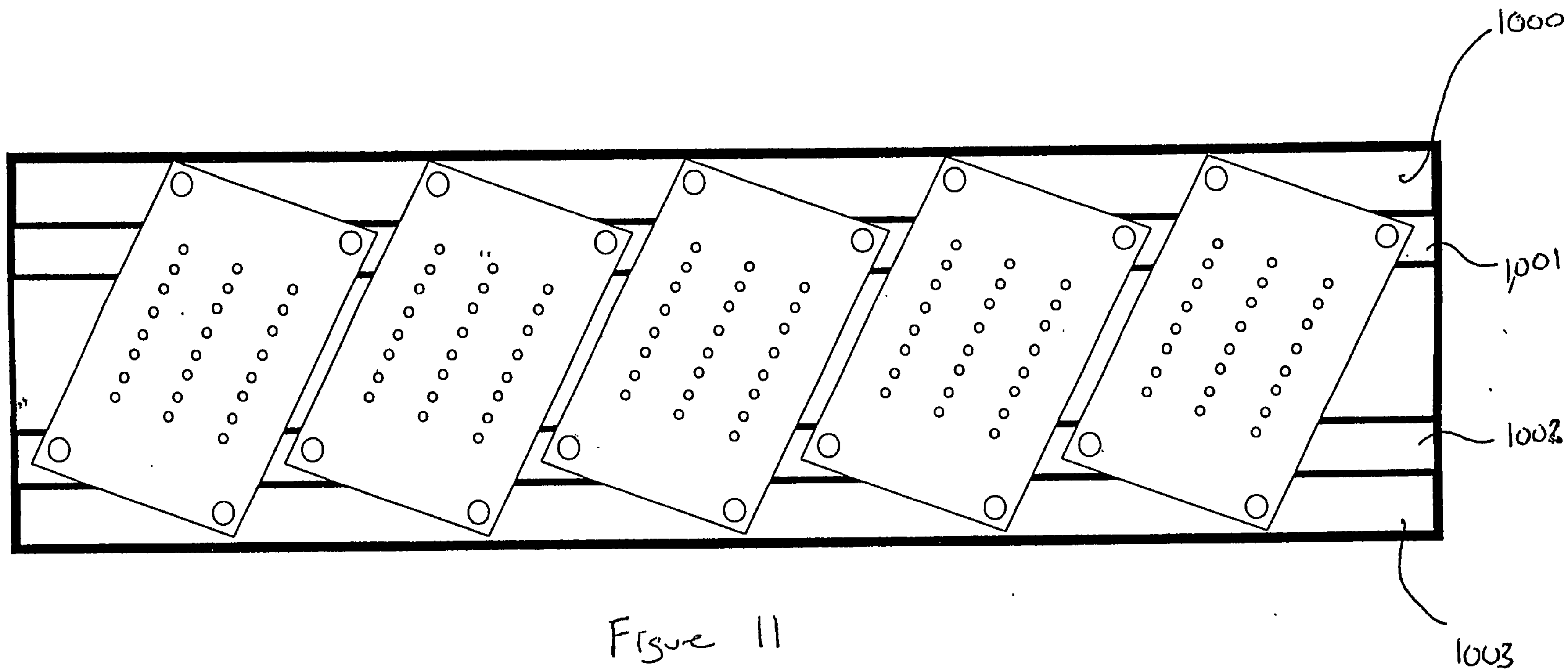


Figure 11

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